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# MECHANICS.

**Conducted by B. F. FINKEL, Springfield, Mo. All contributions to this department should be sent to him.**

## SOLUTIONS OF PROBLEMS.

40. **Proposed by F. P. MATZ, Sc. D., Ph. D., Professor of Mathematics and Astronomy in Irving College, Mechanicsburg, Pennsylvania.**

Find the law of the force, in order that the orbit may be a Cassinian Oval.

**Solution by G. B. M. ZERR, A. M., Ph. D., Texarkana, Arkansas-Texas.**

Let $r^4+2c^2r^2\cos2\theta=m^4-c^4=a^4$......(1) be the equation to the oval. Then $a^4u^4=2c^4u^2\cos2\theta+1$, where $u=1/r$.

$$\frac{du}{d\theta}=\frac{c^2u\sin2\theta}{c^2\cos2\theta-a^4u^2}\;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\;(2).$$

$$\frac{d^2u}{d\theta^2}=\left(\frac{(c^2\sin2\theta\frac{du}{d\theta}+2c^2u\cos2\theta)(c^2\cos2\theta-a^4u^2+(2c^2\sin2\theta+2a^4u\frac{du}{d\theta})c^2u\sin2\theta}{(c^2\cos2\theta-a^4u^2)^2}\right)$$

$$=\left\{\frac{3c^4r^8+10r^4c^4m^4-3r^4c^8-(m^4-c^4)^3-7r^4m^8+9r^8m^4-r^{12}}{r(a^4+2r^4)^3}\right\}.$$

$$F=\text{force}=h^2u^2(u+\frac{d^2u}{d\theta^2})=\frac{h^2}{r^3}+\frac{h^2}{r^2}\cdot\frac{d^2u}{d\theta^2}.$$

$$\therefore F=\frac{h^2(7r^{12}+21r^8m^4+3r^4c^8-9c^4r^8-2c^4m^4r^4-m^8r^4)}{r^3(m^4-c^4+2r^4)^3}$$

$$=\frac{h^2\{7r^9+21m^4r^5-9c^4r^5+3rc^8-2c^4m^4r-m^8r\}}{(m^4-c^4+2r^4)^3}.$$

41. **Proposed by O. W. ANTHONY, M. Sc., Professor of Mathematics, Columbian University, Washington, D. C.**

If the earth were a perfect sphere and had a frictionless surface, what would be the motion of a ball placed at a given latitude?

[No solution of this problem has been received. EDITOR].

42. **Proposed by O. W. ANTHONY, M. Sc., Professor of Mathematics, Columbian University, Washington, D. C.**

Find the time of vibration of a particle slightly displaced from the center of a solid cylinder in direction of the axis, the matter of the cylinder attracting according to the laws of nature.

**Solution by the PROPOSER.**

Consider the particle displaced by the amount $x$ from the center of the cylinder. The matter attracting it will be a cylinder of length $2x$ at the opposite end of the cylinder. Call $y$ the distance of any particle from the axis of cylinder and $z$ the distance of particle from the end of cylinder with length $2x$ measured from the end towards the center.

The attraction of the cylinder upon the particle displaced from the center is

$$A=2\pi\int_0^R\int_0^{2x}\frac{y(a-x+z)dydz}{[(a-x+z)^2+y^2]^{\frac{3}{2}}}.\qquad A=2\pi\int_0^{2x}\left[dz-\frac{(a-x+z)dz}{[(a-x+z)^2+R^2]^{\frac{1}{2}}}\right].$$

$$=4\pi x-2\pi\sqrt{(a+x)^2+R^2}-2\pi\sqrt{(a-x)^2+R^2}$$

$$=4\pi x-2\pi\sqrt{(a^2+R^2)+(x^2+2ax)}-2\pi\sqrt{(a^2+R^2)+(x^2-2ax)}$$

$$=4\pi x-2\pi\{(a^2+R^2)^{\frac{1}{2}}+\tfrac{1}{2}\frac{x^2+2ax}{(a^2+R^2)^{\frac{1}{2}}}+\ldots\ldots\}$$

$$-2\pi\{(a^2+R^2)^{\frac{1}{2}}+\tfrac{1}{2}\frac{x^2-2ax}{(a^2+R^2)^{\frac{1}{2}}}\ldots\ldots\}$$

$$=4\pi x-4\pi(a^2+R^2)^{\frac{1}{2}}-2\pi\frac{x^2}{(a^2+R^2)^{\frac{1}{2}}}\ldots\ldots$$

Since the displacement is to be slight, we may neglect $x^2$ and all higher powers.

$\therefore (d^2x/dt^2)=4\pi x-4\pi(a^2+R^2)^{\frac{1}{2}}=ax-d$, for brevity.

$$\frac{d^2x}{dt^2}=\frac{dv}{dt}=\frac{dv}{dx}\,\frac{dx}{dt}=v\frac{d\dot{v}}{dt}.\quad \therefore v\frac{dz}{dx}=cx-d.\quad v^2=cx^2-2dx+k.$$

When the displacement is a maximum the particle is at rest. Call the amplitude $\alpha$.

$$\text{Then } t=\int_0^a\frac{dx}{\sqrt{cx^2-2dx-c\alpha^2+2d\alpha}}=\int_0^a\frac{dx}{\sqrt{(2d\alpha-c\alpha^2)+(cx^2-2dx)}}$$

$$=\int_0^a[(2d\alpha-c\alpha^2)+(cx^2-2dx)]^{-\frac{1}{2}}dx=\frac{\alpha}{\sqrt{2d\alpha-c\alpha^2}},$$

neglecting higher powers of $x$.

$$=\sqrt{\frac{\alpha}{8\pi\sqrt{a^2+R^2}}},\text{ neglecting the square of }\alpha.$$